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MECHANICAL-PROPERTY DATA TI-6AL-4V ALLOY, POWDER METALLURGY PRO--ETC(U)

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**MECHANICAL-PROPERTY DATA**  
**Ti-6Al-4V ALLOY**

POWDER METALLURGY PRODUCT  
CHIP

Issued by

Air Force Wright Aeronautical Laboratory  
Materials Laboratory  
Wright-Patterson Air Force Base, Ohio

May 1981

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## Ti-6Al-4V Alloy (CHIP)

### Material Description

✓ This Ti-6Al-4V alloy, a powder metallurgy product from Dynamet Technology, was received as sixty 5/8" diameter x 5" bars, seven 0.125" x 2" x 12" strips, and nine 3/4" x 3" x 3" blanks.

✓ The chemical composition of this lot is ~~as follows:~~ *per the Test.*

<u>Chemical Composition</u>	<u>Percent Weight</u>
Aluminum	5.70
Vanadium	4.22
Carbon	0.024
Hydrogen	0.0013
Nickel	0.0112
Oxygen	0.19
Others	0.043
Titanium	Balance.

### Processing and Heat Treating

The Ti-6Al-4V alloy was received in the "CHIP"ed condition. "CHIP" (Cold Hot Isostatically Pressed) processing means the material was cold isostatically pressed at 60,000 psi (413.7 MPa), vacuum sintered at 2250 F (1505 K) for 3 hours and furnace cooled, and hot isostatically pressed at 15,000 psi (103.4 MPa) at 1650 F (1172 K) to achieve the desired density and mechanical properties.

*Processing and Heat Treating*  
✓ Results of ~~this~~ evaluation show slightly lower strength values than for the wrought annealed material. The tensile and compression results were slightly lower while the bearing and shear results were slightly higher.

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## Ti-6Al-4V

Condition: CHIP<sup>(a)</sup>

Properties	Temperature, F (K)					
	RT	(RT)	400	(477)	800	(700)
<u>Tension</u>						
TUS, ksi (MPa)	127.4	(878.4)	96.0	(661.9)	76.6	(528.2)
TYS, ksi (MPa)	115.8	(798.4)	83.2	(573.7)	60.4	(416.5)
RA, percent	12.2	(12.2)	16.1	(16.1)	26.7	(26.7)
e, percent in 1 in. (25.4 mm)	6.7	(6.7)	7.0	(7.0)	10.8	(10.8)
E, 10 <sup>3</sup> ksi (GPa)	16.9	(116.5)	15.7	(108.3)	13.6	(93.8)
<u>Compression</u>						
CYS, ksi (MPa)	123.8	(853.6)	83.3	(574.4)	61.0	(420.6)
E <sub>c</sub> , 10 <sup>3</sup> ksi (GPa)	15.9	(109.6)	15.0	(103.4)	13.2	(91.0)
<u>Shear</u>						
SUS, ksi (MPa)	88.8	(612.3)	71.3	(491.5)	55.3	(381.4)
<u>Bearing</u>						
e/D = 1.5						
BUS, ksi (MPa)	212.6	(1465.7)	154.6	(1065.8)	151.1	(1041.8)
BYS, ksi (MPa)	209.7	(1446.1)	142.8	(984.3)	120.6	(831.4)
e/D = 2.0						
BUS, ksi (MPa)	262.0	(1806.0)	195.4	(1347.6)	192.6	(1328.3)
BYS, ksi (MPa)	242.0	(1669.0)	173.5	(1196.1)	140.7	(970.3)
<u>Fracture Toughness</u>						
K <sub>IC</sub> , ksi√In. (MPa·m <sup>1/2</sup> )	36.7 <sup>(b)</sup>	(40.4)	NA <sup>(c)</sup>		NA	
<u>Axial Fatigue</u>						
Unnotched, R = 0.1						
10 <sup>3</sup> cycles, ksi (MPa)	124	(854)	NA		73	(503)
10 <sup>5</sup> cycles, ksi (MPa)	64	(441)			48 <sup>(d)</sup>	(331)
10 <sup>7</sup> cycles, ksi (MPa)	45 <sup>(d)</sup>	(310)			35 <sup>(d)</sup>	(241)
Notched, K <sub>t</sub> = 3.0, R = 0.1						
10 <sup>3</sup> cycles, ksi (MPa)	(e)		NA		62 <sup>(d)</sup>	(427)
10 <sup>5</sup> cycles, ksi (MPa)	34	(234)			25	(172)
10 <sup>7</sup> cycles, ksi (MPa)	19	(131)			15	(103)

Ti-6Al-4V (Continued)

Properties	Temperature, F (K)				
	RT	(RT)	400	(477)	800 (700)
<u>Creep</u>					
0.2% plastic deformation, 100 hr, ksi (MPa)	NA		NA		47.5 (327.5)
0.2% plastic deformation, 1000 hr, ksi (MPa)	NA		NA		34.0 (234.4)
<u>Stress Rupture</u>					
Rupture, 100 hr, ksi (MPa)	NA		NA		50.0 (344.7)
Rupture, 1000 hr, ksi (MPa)	NA		NA		42.1 (290.3)
<u>Stress Corrosion</u> (f)					
$K_{ISCC} - 15 \text{ ksi}\sqrt{\text{in.}} \text{ (16.5 MPa}\cdot\text{m}^{1/2}\text{)}$					
<u>Coefficient of Thermal Expansion</u>					
$6.0 \times 10^{-6} \text{ in./in./F (70 - 800 F) [10.8} \times 10^{-6} \text{ m/(m}\cdot\text{k) (295 - 700 K)]}$					
<u>Density</u>					
$0.159 \text{ lb./in.}^3 \text{ (4.41 g/cm}^3\text{)}$					

- (a) Cold isostatically pressed, vacuum sintered and hot isostatically pressed. Values are average of triplicate tests conducted at Battelle under the subject contract unless otherwise indicated. Fatigue, creep, and stress-rupture values are from curves generated using the results of a greater number of tests.
- (b)  $K_{IC}$  is valid as per ASTM E399.
- (c) NA, not applicable.
- (d) Estimated.
- (e) Insufficient tests to estimate.
- (f) This value is an approximate determination of  $K_{ISCC}$  at  $10^{-8} \text{ in./sec.}$  ( $25.4 \times 10^{-8} \text{ mm/sec.}$ ). The increasing K tests lasted an average of 3 days and were conducted at 75 F (297 K) in 3-1/2% NaCl. Compact-tension-type specimens were used.

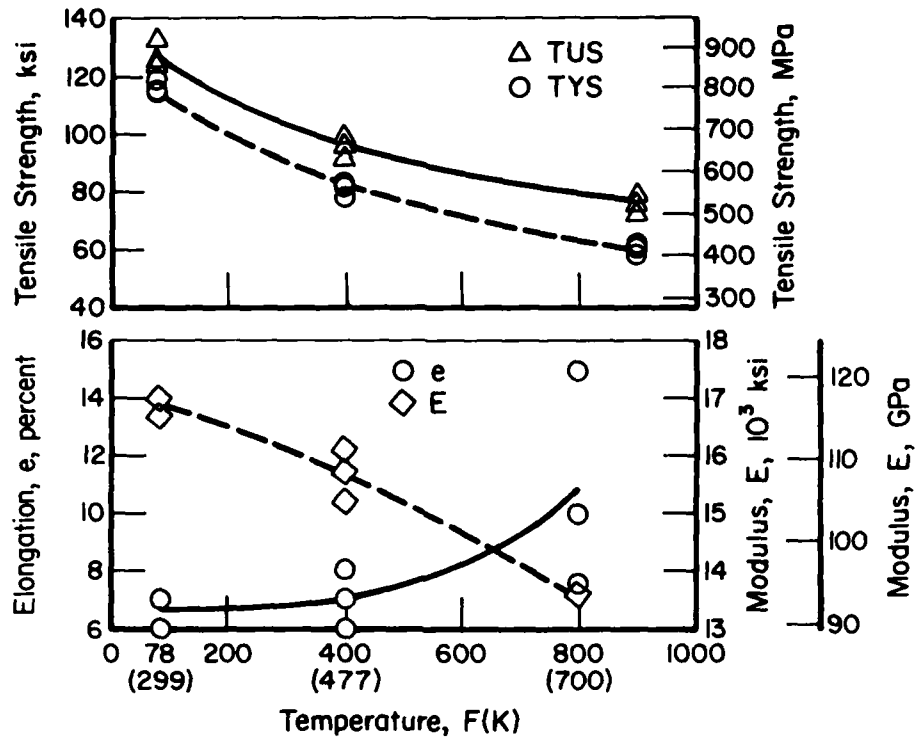


Figure 1. Effect of temperature on the tensile properties of Ti-6Al-4V (CHIP) Alloy.

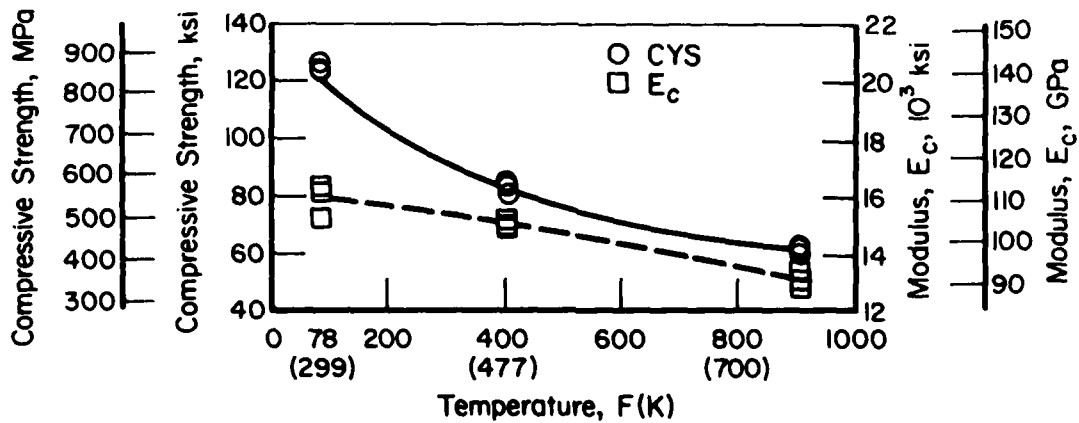


Figure 2. Effect of temperature on the compressive properties of Ti-6Al-4V (CHIP) Alloy.

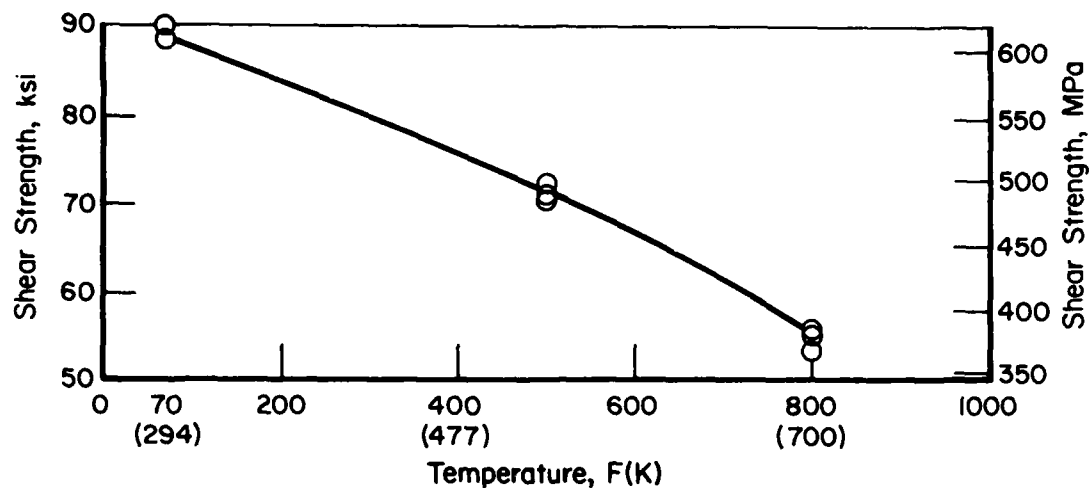


Figure 3. Effect of temperature on the pin shear properties of Ti-6Al-4V (CHIP) Alloy.

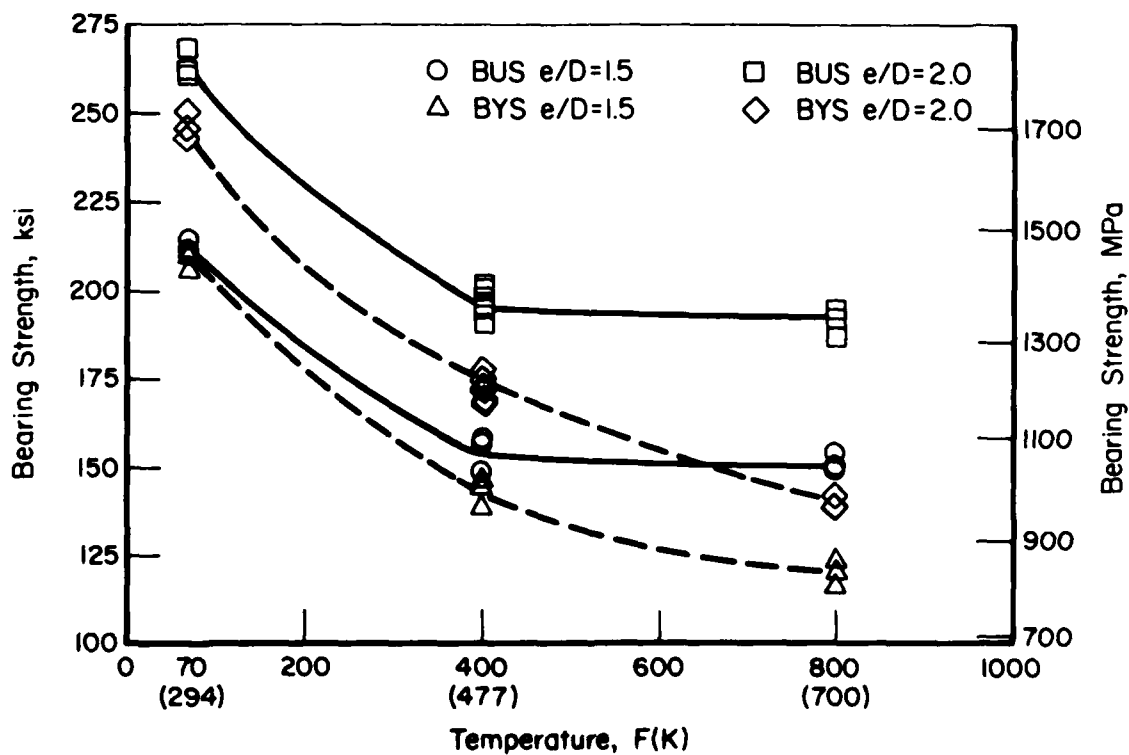


Figure 4. Effect of temperature on the bearing properties of Ti-6Al-4V (CHIP) Alloy.



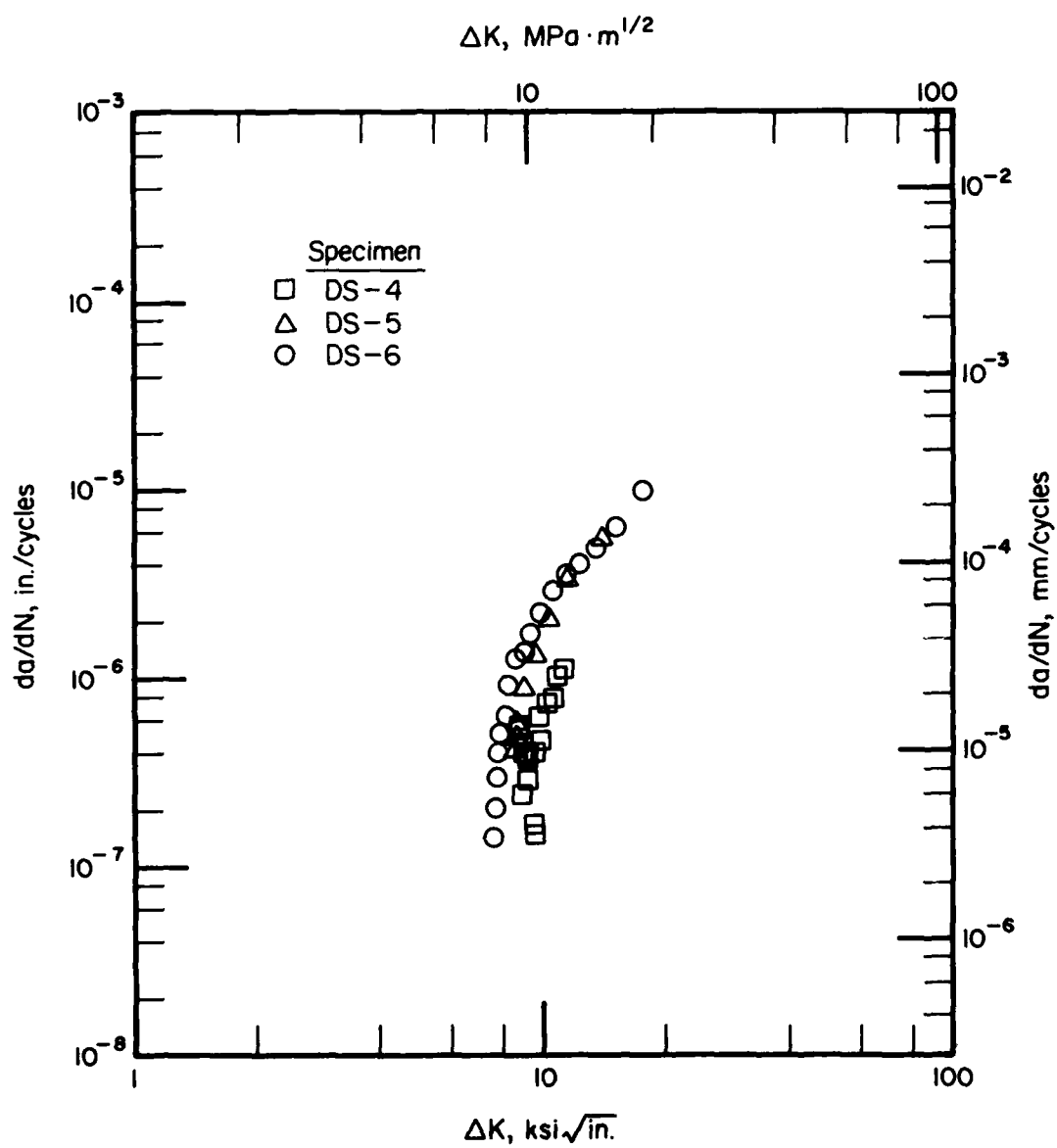


Figure 5.  $da/dN$  versus  $\Delta K$  for Ti-6Al-4V (CHIP) Alloy.

Lab Air  
 $R = 0.1$   
 Frequency = 20 Hz

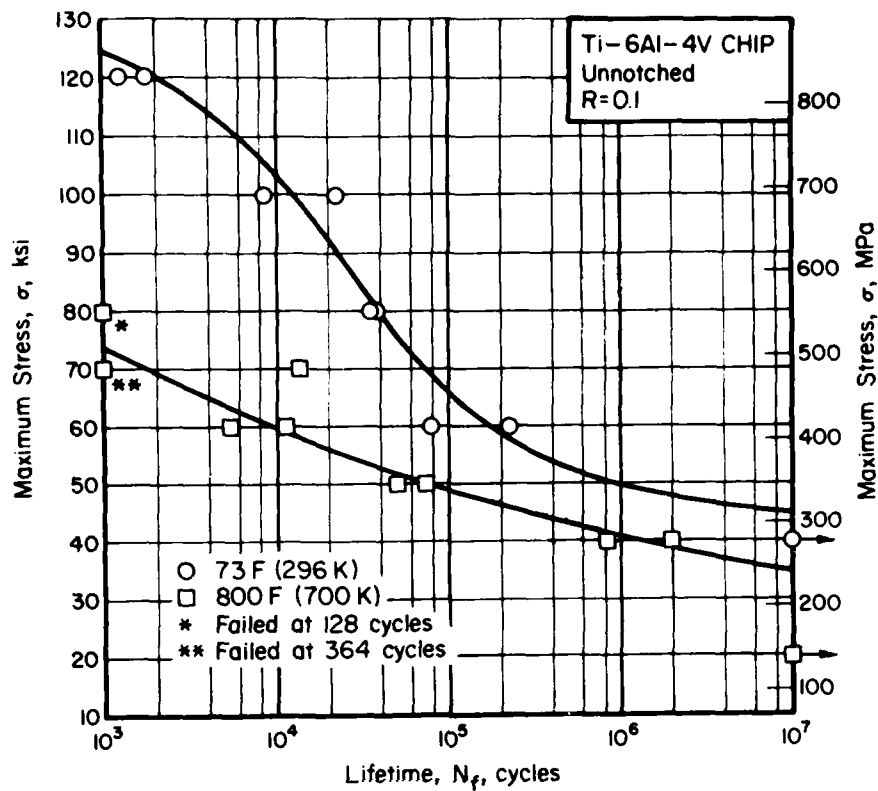


Figure 6. Axial load fatigue behavior of unnotched Ti-6Al-4V (CHIP) Alloy.

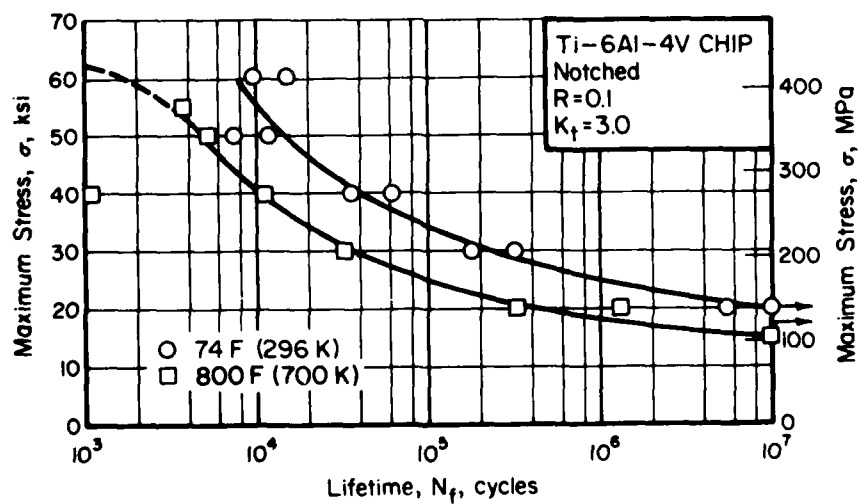


Figure 7. Axial load fatigue behavior of notched ( $k_t = 3.0$ ) Ti-6Al-4V (CHIP) Alloy.

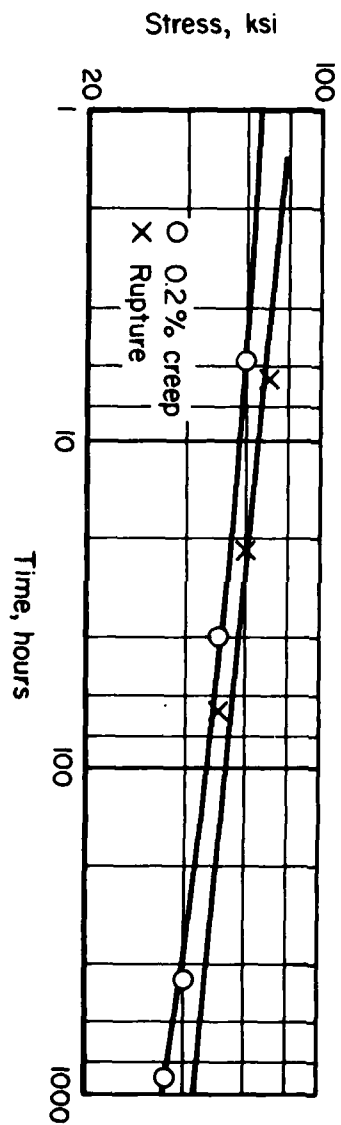


Figure 8. Stress-rupture and plastic deformation curves for Ti-6Al-4V (CHIP) Alloy.

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